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(54) SYSTEM CONNECTING THE EXTRACTION PLANT AND THE CENTRIFUGAL SEPARATOR CIRCUIT IN THE HOT WATER PROCESS FOR TAR SANDS

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ABSTRACT

Bitumen froth from a hot water process extraction plant is fed into a large surge tank in which it is retained for at least one hour while mixing. The froth is then fed by a variable speed pump through a feed conduit to a distributor vessel connected to scroll centrifuge separators. The pressure changes within the distributor vessel are monitored and used to regulate the pump to prevent froth surges at the separators. Naphtha is introduced into the feed line to mix with the froth. The viscosity of this mixture is monitored and used to regulate the naphtha addition to maintain a constant diluent/bitumen ratio in the diluted froth. The system supplies the diluted froth to the separators at a feed rate and with a composition which vary only slowly.

This invention relates to a method for treating bitumen froth moving from a hot water process extraction plant to a battery of centrifugal separators.

One of the world's largest reservoirs of hydrocarbons is the Athabasca tar sand deposit in Northern Alberta. The oil or bitumen from this deposit is presently being extracted using the known hot water process.

In general terms, this process involves mixing tar sand with water and steam in a rotating tumbler to initially separate the bitumen from the water and solids of the tar sand and to produce a slurry. The slurry is diluted with additional water as it leaves the tumbler and is introduced into a cylindrical primary settler vessel having a conical bottom. The coarse portion of the solids settles out in this vessel and is removed as an underflow and discarded. Most of the bitumen and minor amounts of solids and water rise to the surface of the vessel contents to form a froth. This froth overflows the vessel wall and is received in a launder extending around its rim. The froth is termed primary froth. A middlings stream, comprising water, fine solids (-325 mesh), and a minor amount of buoyant and non-buoyant bitumen, is withdrawn from the mid-section of the vessel and is pumped to a sub-aeration flotation cell. Here the middlings are relatively violently agitated and aerated. The middlings bitumen becomes attached to the air bubbles and rises through the cell contents to form a froth. This froth, termed secondary froth, is recovered in a launder and settled to reduce its water and solids content. The primary froth and settled secondary froth are combined and preferably deaerated in a column with steam to provide the feed stock for this invention. Typically the feed stock froth comprises 62% bitumen, 29% water and 9% solids. The temperature of froth after deaeration is typically 185°F.

Following deaeration, the froth is pumped through a feed conduit to a two-stage centrifugal separation circuit. A hydrocarbon diluent is injected into the feed conduit to mix with the froth. The diluent, usually naphtha, is added to reduce the viscosity and specific gravity of the froth bitumen phase to render it amenable to centrifugal separation. In the first stage of the circuit, the diluted froth is treated in one of a battery of scroll-type separators. These separators remove most of the coarse solids from the froth. The product is then passed through one of a battery of disc-type separators to remove the remaining fine solids and the water and produce a relatively clean diluted bitumen stream.

In accordance with the prior art, the froth has been pumped to the scroll-type separators through a feed conduit terminating in a loop. The loop feeds a series of separators individually connected thereto. A recycle pump is included in the loop. This pump keeps the diluted froth moving through the loop and prevents suspended solids from settling out and plugging the line. However the pump induces increased emulsification of the diluted froth and thereby reduces the efficiency of the centrifugal separation process.

Another problem which affects the operation of the scroll-type centrifuge battery has to do with surges in the feed rate of the diluted froth fed to the individual separators. If one of the scroll-type separators goes down, there is a surge in feed rate to the remaining operating separators. This increase in feed rate is accompanied by an increase in torque experienced by the machines. Frequently a shear pin, protecting a separator's drive system against excessive torque, will part, thereby rendering the machine inoperative. If the change in feed rate conditions is not sensed and corrected quickly, the entire battery of separators

may be shut down.

Another problem arises from the operation of the bitumen extraction plant. It is subject to variations in tar sand feed composition and flow rate. For example, the bitumen content of the mined tar sand can vary between 8% and 13% by weight. In addition, the mine itself can be subject to frequent shut-downs due to mechanical problems. These sudden changes are reflected in changes in froth composition and feed rates; these latter changes deleteriously affect the operation of the dilution centrifuging circuit. This is particularly the case with the disc-type separators, which require steady feed conditions for best operation.

Still another problem associated with a dilution centrifuging circuit arises from the lack of instrumentation, applicable in a practical sense, available for accurately and quickly determining the flow rate of bitumen through the feed conduit. Because the bitumen content of the froth cannot presently be easily determined, due to the presence of water and solids, it is difficult to ensure a substantially constant and desirable diluent/bitumen ratio in the diluted froth. More particularly, it is found that a low diluent/bitumen ratio tends to make operation of both sets of centrifuges difficult - that is, the machines require a good deal of operator attention in this circumstance. Further, a low diluent/bitumen ratio reduces the separation efficiency of the machines. Due to these problems, there is a tendency on the part of the operators to seek to err on the side of too high a diluent/bitumen ratio, thereby wasting diluent. In addition, a too high diluent/bitumen ratio reduces the efficiency of the centrifugal separators. There is therefore required an accurate and practical system for monitoring the ratio so that it can be accurately maintained at the desired level.

With the foregoing in mind, it is the principal object of this invention to provide a method whereby the stream of bitumen froth delivered to the separators varies only slowly in composition.

It is a preferred object to provide a method whereby the stream of bitumen froth is delivered to the separators at a generally constant flow rate.

It is another preferred object to provide a method whereby the diluent/bitumen ratio of the diluted froth is effectively monitored, so that the addition of diluent may be controlled to ensure that the ratio is held substantially constant.

It is another preferred object to provide a method whereby a stream of diluted bitumen froth is supplied to the separators, said stream having a composition which varies only slowly and has a generally constant diluent/bitumen ratio, said stream being supplied at a generally constant rate and pressure.

In accordance with the broadest aspect of the invention, at least the major portion of the bitumen froth is retained and mixed in a surge tank for at least an hour. It has been found that, when this is done, neither segregation or coalescence of the froth components occurs to a seriously deleterious degree, as would have been expected. As a result of retaining and mixing the froth, variations in froth composition and flow rate are smoothed out, so that the separators receive a stream whose composition and flow rate change only slowly. As a result, the operation of the separators is improved. Our work indicates that the degree of segregation and coalescence, which occurs when the froth is retained and mixed, diminishes if the temperature of the froth is higher than about 150°F. We prefer to use a froth having a temperature

of about 185°F.

In a preferred feature of the invention, the viscosity of the diluted bitumen froth is measured in a novel manner. It has been found that these measurements are indicative of the relative viscosity of the continuous hydrocarbon phase in the froth. Surprisingly, the presence of varying amounts of solids and water in the froth does not seriously affect this relationship. The addition of diluent to the undiluted froth is controlled in response to these measurements. As a result, the diluent/bitumen ratio in the diluted froth can be maintained substantially constant at a desirable value.

In another preferred feature of the invention, the feed conduit terminates in a distributor vessel, which is connected by an upwardly extending connector pipe with each of the scroll-type separators. In this manner, the need for a circulating pump is eliminated. The pressure within the vessel is monitored and the speed of the surge tank pump varied in response thereto to further improve the control over surging at the separators.

Broadly stated, the invention is an improvement on the process wherein bitumen froth, comprising bitumen, water and solids, is transferred through a feed conduit from a hot water process extraction plant to a battery of centrifugal separators and diluted with hydrocarbon diluent as it moves between the plant and the battery. The improvement comprises temporarily retaining at least the major portion of the undiluted froth being transferred in a surge tank for at least one hour and mixing the retained froth with incoming froth without significant segregation or coalescence of froth components within the tank, thereby producing a froth product stream whose composition and flow rate change only slowly.

In the drawing:

Figure 1 is a schematic diagram illustrating the system; and

Figure 2a is a plot of the hydrocarbon phase viscosity of diluted froth as a function of the naphtha-bitumen ratio;

Figure 2b is a plot of tubing viscometer readings taken on diluted froth as a function of naphtha-bitumen ratio.

With reference to Figure 1, deaerated bitumen is continuously delivered from an extraction plant or source 1 to a froth surge tank 2. The surge tank 2 is preferably only partially filled and is of sufficient capacity so that the retention time therein is in the order of at least 1 hour, preferably 2 - 3 hours. A plurality of side entry mixers 3 extend into the tank 2 for turning its contents over several times while the froth passes therethrough.

On leaving the surge tank 2, the froth is pumped through the feed conduit 4 by a variable speed feed pump ~~2~~ 5.

Naphtha or like diluent is introduced into the froth feed conduit 4 before it reaches the scroll centrifuge battery 6. More particularly, naphtha is fed by a centrifugal pump 7 from a storage tank 8 through a conduit 9 into feed conduit 4.

The flow of naphtha through the conduit 9 is controlled by a valve 10 on the discharge of a naphtha heater. The rate of naphtha flow is measured by an orifice meter 12 ahead of the heater. The flow of combined naphtha and froth (i.e. diluted froth) through the feed conduit 4 is also measured with an orifice meter 13 downstream of the froth-naphtha junction 20. The flow of naphtha is regulated as a pre-set ratio of the diluted froth flow by a flow ratio controller 14, connected to the meters 12, 13. The flow ratio controller 14 operates to control the valve 10.

A viscometer 15 operates to provide a viscosity controller 14a with a signal indicative of the viscosity of the diluted froth. The viscosity signal is utilized by the viscosity controller 14a to re-set the naphtha/froth ratio setpoint on the flow ratio controller 14 in order to maintain the diluted froth at a more or less constant viscosity.

The viscometer 15 comprises a positive displacement pump 16 which withdraws a sample at a constant rate from the diluted froth conduit 4 and pumps it through a conduit loop 17 and back into the conduit 4. A differential pressure cell 18 measures the pressure drop across the loop 17 and transmits the required proportional signal to the viscosity controller 14a. A suitable viscometer is obtained by using a 3L2 Moyno pump and a 25 foot long loop of 3/8 inch inside diameter tubing.

It has been found that variations in the viscosity of the diluted froth arise largely from variations in the bitumen content of the froth. So little variation in the froth viscosity arises from changes in the solids and water contents thereof that they can be ignored. The froth viscosity measurement can therefore be used as an indicator of the relative viscosity of the hydrocarbon phase in the diluted froth.

The diluted froth conduit 4 terminates in a distributor vessel 19. This vessel 19 has upwardly inclined connector lines 20, each leading to a scroll centrifuge 21. A pressure sensor 22 monitors the pressure within the distributor vessel 19 and transmits a signal proportional thereto to a controller 23 which regulates the speed of the froth feed pump 5 to reduce pressure surges at the vessel 19.

The present system is characterized by several advantages. By providing a large froth surge tank and blending its contents, wide fluctuations in the froth composition and flow rate are evened out so that changes occur only gradually.

This improves the operation of the separator circuit. In addition, as a result of providing surge capacity, it is possible to use a fast-acting pressure responsive system to control the froth feed pump and minimize surge conditions at the scroll separators. By monitoring the viscosity of the diluted froth, it is possible to maintain the diluent/bitumen ratio generally constant at a pre-determined value. This improves the efficiency of the separators and conserves diluent. Finally, by using a distributor vessel, emulsification of the diluted froth is reduced. Not all of these advantages need be incorporated in a system. As stated, the broadest aspect of the invention is the concept of retaining and mixing the undiluted froth. However it is preferable to incorporate the other features of the invention as well.

Certain aspects of the invention are exemplified by the following data:

Example I

The usefulness of agitating froth to improve its homogeneity can be illustrated by comparing the standard deviation of the water content (or solids content) of unagitated diluted froth with the standard deviation of the water content (or solids content) of agitated diluted froth. Typically, the mean of the water and solids contents of diluted froth from average tar sand as well as their standard deviations, both in the agitated and unagitated states are as follows.

	UNAGITATED FROTH		AGITATED FROTH	
Component	Mean	Std. Dev.	Mean	Std. Dev.
Water	26.27%	5.46%	27.79%	3.37%
Solids	7.56%	5.72%	6.06%	0.93%

As shown in the tables above, the expected solids content of a random sample of unagitated diluted froth could vary from 1.84% to 13.28% while the expected solids contents of a random

sample of agitated diluted froth could vary only from 5.13% to 6.99%.

Example II

The viscometer data shown in Figures 2a and 2b show that the tubing viscometer, when applied to bitumen froth, does, in fact, give readings indicative of the hydrocarbon phase viscosity. Figure 2a shows the hydrocarbon phase viscosity of naphtha-bitumen samples (which were taken during tubing viscometer tests) as a function of the naphtha/bitumen ratio. The data illustrated in Figure 2b shows the actual tubing viscometer readings as a function of naphtha/bitumen ratio. It will be noted that the curves are similar in shape. Comparison of the low water froth data with the high water froth data in Figure 2b shows that the viscosity readings (between high and low water froth) vary by a maximum of 10% while the water content of the froth varied from 27% to 47%. Figure 2b also illustrates that the tubing viscometer can be made more insensitive to the froth water content by providing the viscometer with a long residence time suction device (30 sec.) thereby allowing some of the water to separate from the hydrocarbon before the mixture enters the tubing downstream of the pump. By "suction device" is meant an upwardly inclined (45°) suction pipe extending from the centre of the froth line to the centrifugal pump supplying the viscometer loop. A 2 1/2" diameter suction pipe was used to provide a "long residence time", thereby allowing some solids and water to settle out of the sample and slide back to the froth line. A 1/4" diameter suction pipe was used to provide a "short suction time".

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A method for transferring bitumen froth, comprising bitumen, water and solids, through a feed conduit from a hot water process extraction plant source to a battery of scroll-type centrifugal separators comprising:

supplying bitumen froth from the plant source to a surge tank connected with the feed conduit;

temporarily retaining such undiluted froth in the surge tank and mixing the retained froth in the tank with incoming froth;

pumping a froth product stream from the surge tank through the feed conduit with a variable speed pump to means for distributing the stream into the separators and distributing said product into the separators;

introducing hydrocarbon diluent into the feed conduit downstream of the surge tank to mix with the froth product stream and reduce the viscosity and specific gravity of the contained bitumen so that the froth is amenable to centrifugal separation to separate its components;

monitoring pressure changes within the distributor means; and

adjusting the speed of the pump responsive to said pressure changes to provide diluted froth, having a composition which varies only slowly, to the separators at a substantially constant rate.

2. A method for transferring bitumen froth, comprising bitumen, water and solids, through a feed conduit from a hot water process extraction plant source to a battery of scroll-type centrifugal separators comprising:

supplying bitumen froth from the plant source to a surge tank connected with the feed conduit;

temporarily retaining such undiluted froth in the surge tank and mixing the retained froth in the tank with incoming froth;

pumping a froth product stream from the surge tank through the feed conduit with variable speed first pump means to means for distributing the stream into the separators;

introducing hydrocarbon diluent, through a feed line having variable speed second pump means, into the feed conduit downstream of the surge tank to mix with the froth product stream and reduce the viscosity and specific gravity of the contained bitumen so that the diluted froth is amenable to centrifugal separation to separate its components;

establishing the relative viscosity of the hydrocarbon phase in the diluted froth; and

varying the speed of the second pump means, and thus the flow rate of diluent being introduced into the feed conduit, in response to said relative viscosity to maintain the diluent/bitumen ratio of the diluted froth substantially constant.

3. The method as set forth in claim 1 wherein:

the undiluted froth transferred to the surge tank is at a temperature of at least 150°F and is supplied on a continuous basis.

4. A method for transferring bitumen froth, comprising bitumen, water and solids, through a feed conduit from a hot water process extraction plant source into a battery of scroll-type centrifugal separators comprising:

supplying bitumen froth from the plant source to a surge tank and mixing the retained froth in the tank with incoming froth;

pumping a froth product stream from the surge tank through the feed conduit with variable speed first pump means to means for distributing the stream into the separators;

monitoring the pressure changes within the distributor means;

adjusting the speed of the first pump means responsive to said pressure changes;

introducing hydrocarbon diluent, through a feed line having variable speed second pump means, into the feed conduit downstream of the surge tank to mix with the froth product stream and reduce the viscosity and specific gravity of the contained bitumen so that the diluted froth is amenable to centrifugal separation to separate its components;

establishing the relative viscosity of the hydrocarbon phase in the diluted froth; and

varying the speed of the second pump means, and thus the flow rate of the diluent being introduced into the feed conduit, in response to said relative viscosity to maintain the diluent/bitumen ratio of the diluted froth substantially constant.

5. The method as set forth in claim 2 comprising:

providing the froth to the surge tank at a temperature of at least 150°F and retaining at least part of such froth in the surge tank for at least one hour.

6. The method as set forth in claim 4 comprising:

providing the froth to the surge tank at a temperature of at least 150°F and retaining at least part of such froth in the surge tank for at least one hour.

Fig.1

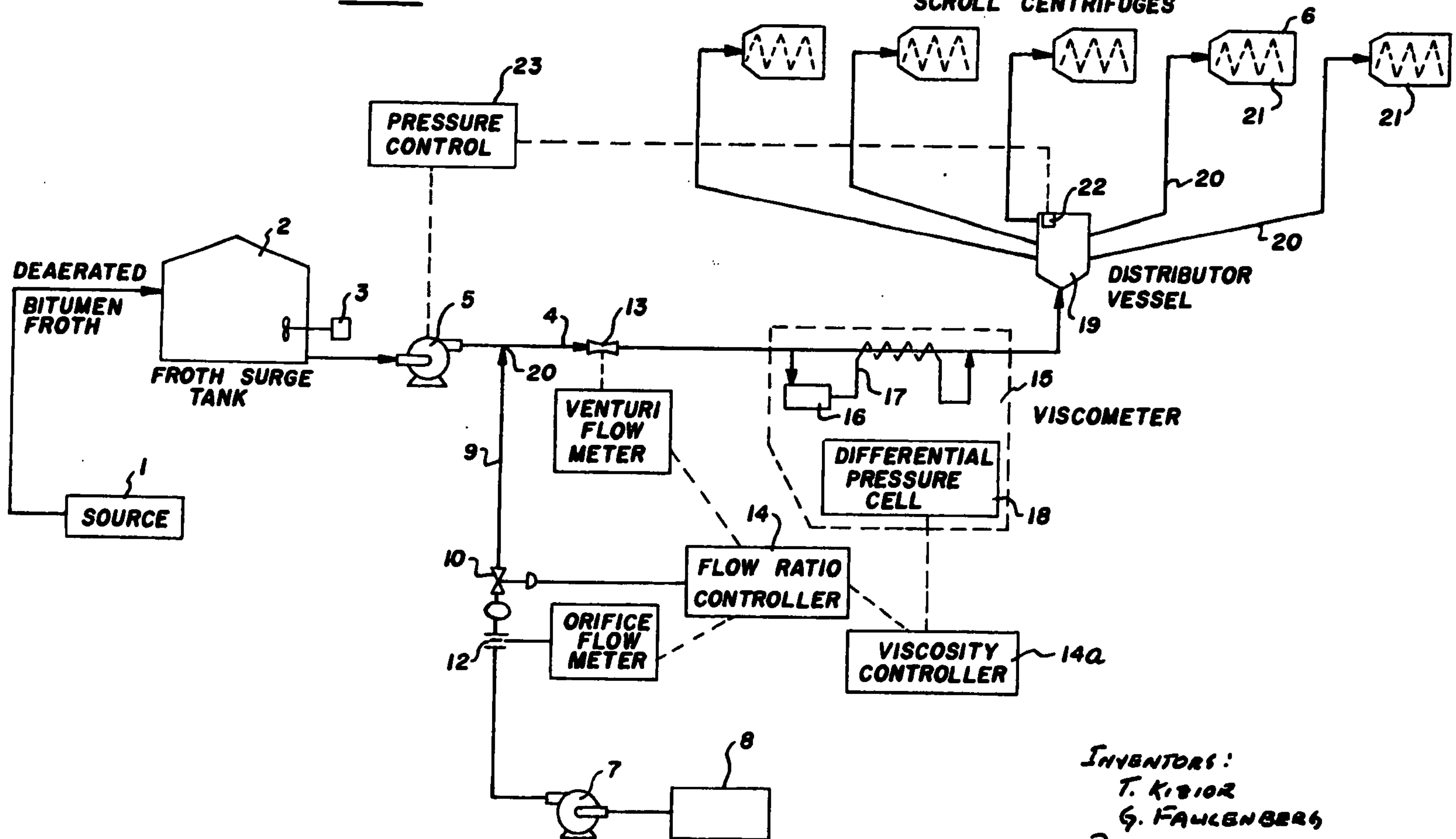

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Fig. 2a.

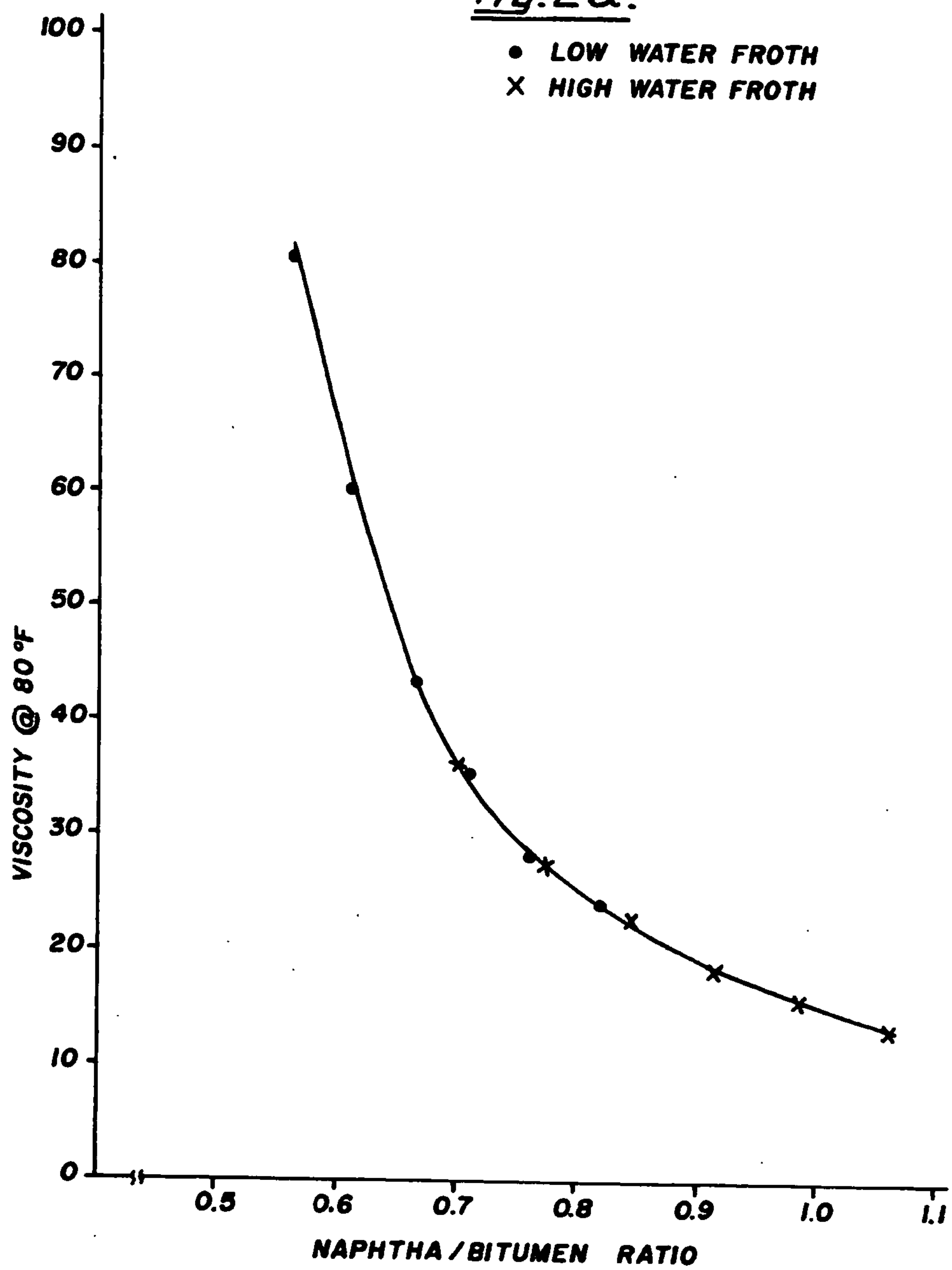

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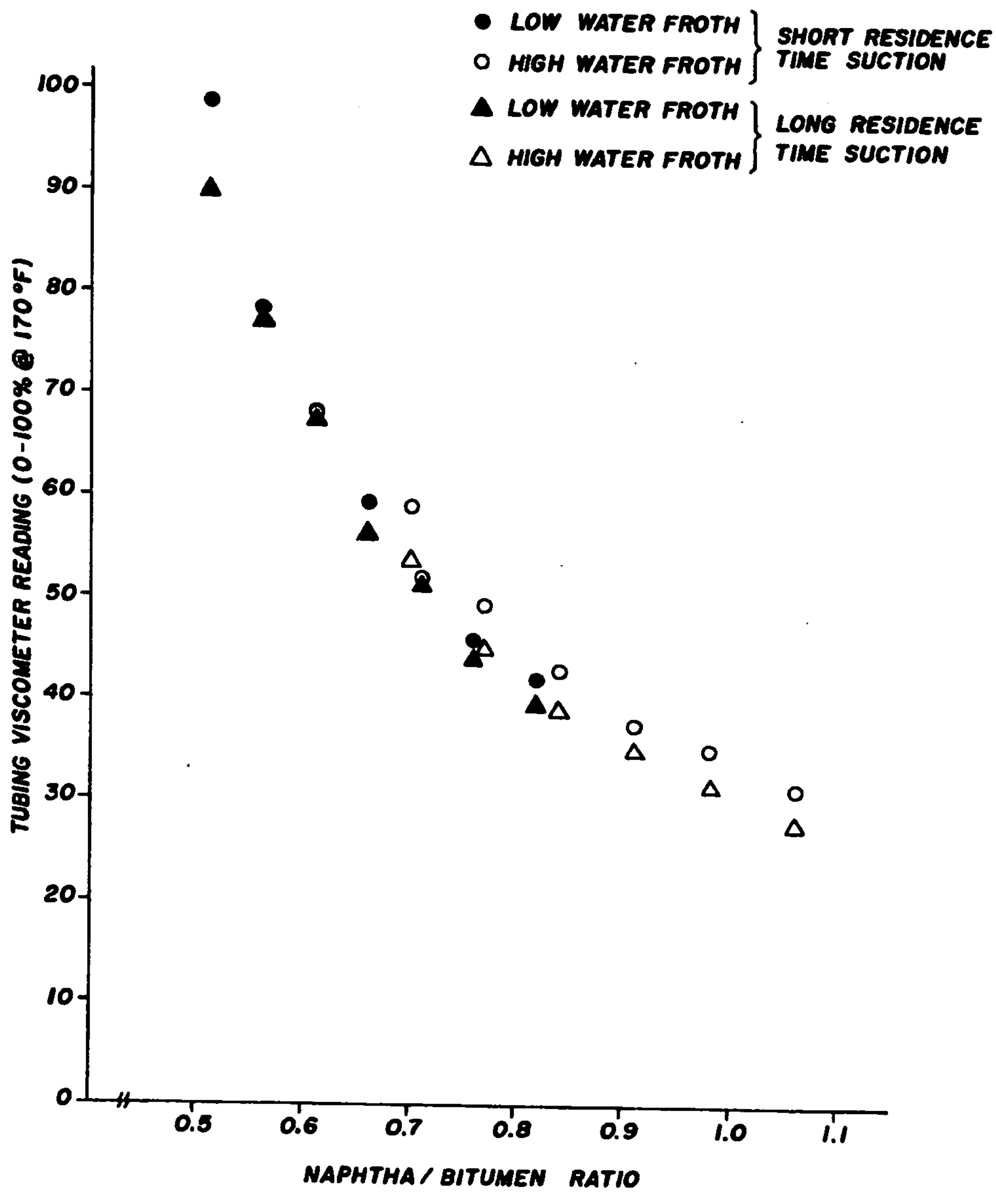
Fig. 2b.



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